upper Edge of the ſhade Vane, to the Sun, and it will give what is required: The ſame Rule is to be obſerved in taking the Altitude of a Star.

II. *The Deſcription and Uſe of an Apparatus added as an Improvement to* Davis's *Quadrant, conſiſting of a* Mercurial Level, *for taking the Co-altitude of Sun or Star at Sea, without the uſual Aſſiſtance of the ſenſible Horizon, which frequently is obſcured. By* Charles Leigh, *Gent.*

I Had the Honour ſome time ago, [*Nov.* 3. 1737.] to communicate to this learned Society, an Invention much upon the ſame Nature and Principle with this; ſince which I have made ſuch Alterations and Improvements thereto, as have render'd it complete and perfect for the Uſe intended, and have been confirmed by repeated Experiments, as well on board Ships, as on Shore. An Inſtrument of this Nature we greatly want at Sea, and it would be a great Satisfaction to me, if any Thoughts and Inventions of mine ſhould contribute to the removing of this grand Impediment, that ſo frequently happens.

To arrive to the utmoſt Perfection in Navigation, three things are abſolutely requiſite, *viz.* The Variation, the Latitude, and the Longitude; which laſt is, as yet, conceal'd from us. The two former indeed, we

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we have a tolerable Certainty of, eſpecially the firſt, which may be found by Obſervation, almoſt at any time the Sun ſhall be viſible in or above the Horizon, either by an Amplitude or Azimuth; but unhappily as yet, it is not ſo in regard to the Latitude, by any certain Method, but what is looked on as too abſtruſe for common Practice; for it is but *once* in 24 Hours that an Obſervation can be made from the Sun, and even that Space of Time ſo very ſhort, that if the Horizon ſhould then be obſcured, or a Cloud intercept the Rays of the Sun, the dead Reckoning is then the only Guide, which, in Fact, is little better than grope-ing in the Dark.

Since the Latitude then is our principal Guide at preſent, and liable to theſe Obſtructions, it would be unneceſſary to inlarge on the Advantages that would accrue to Navigation from Improvements tending to obviate them. As this Invention removes a very material Obſtacle, *viz.* an obſcure Horizon, there remains another, which, I hope and believe, is not altogether impracticable to remove; and that is, being confined but to one ſhort Space of Time for Obſervation, as already mention'd; and doubtleſs it would be of great Advantage to Navigation, could an accurate Method be found for diſcovering the Latitude as frequently in the Day, as you may that of the Variation.

But to return to the Inſtrument under Conſideration, which is founded on this obvious Principle, *viz.* "That the Surfaces of all Liquids, that have a Com-"munication with each other, though ſeparated at "any Diſtance in their Surfaces, will be in a true "horizontal Plane."

The

The firſt Inſtrument that I made conformable to this Principle, was with a Water-Level; but finding that Water was ſubject to ſome Inconveniencies, I altered the Apparatus, and changed the Fluid from Water to Mercury: This Alteration and Improvement will more intelligibly appear by the Inſtrument, and alſo the Draught hereunto ſubjoined, Tab. I. Fig. 1. where *AB*, *CD*, repreſents the Segments of two different Circles that are concentrick; *E*, the common Centre, in which moves the Pin or Axis fitted to the Index or Label *EF*; on which Label is alſo fix'd the horizontal Tube *Gg*, which has a Communication with the two glaſs vertical Tubes *Eh*, *dh*, in which moves the Mercury. On each Top of the vertical Tubes are fix'd a large hollow braſs Cylinder *hh*, having in their Tops a Pin, by cloſing of which, the included Air is prevented from any Communication with the External; by which means this Advantage is obtained, that it prevents, in a great meaſure, that too quick and vibratory Motion that is natural to the Fluidity join'd to the Gravity of Mercury when moved, and at the ſame time, by having a ſufficient Space and Quantity of Air in the Cylinders at Top, does not in the leaſt impede the true Level; but notwithſtanding this Precaution, the Mercury ſtill would be ſubject to a tremulous Motion, were it not that the Diameters of the vertical Tubes, to that of the horizontal, are as 2 to 1, and conſequently the Area 4 to 1; by which means this Inconveniency is alſo removed, without any way affecting the horizontal Level.

The firſt trimming or preparing the Tubes with Mercury is ſufficient, and when the two little convex Surfaces of the Mercury appear juſt viſible above the level

level Rings *E e*, then is the Inſtrument correctly trimm'd; if they appear much above or below the Rings, move the Tubes a little up or down, till the Surfaces are adjuſted to the Rings; which is effected by means of the regulating Screw *l*, fix'd at the End of the Baſe Tube.

As I well know the Fondneſs our Navigators have to *Davis*'s Quadrant, I adapted the Apparatus to this Inſtrument, which is ſo far from being perplexing, that it becomes obvious at firſt View, and by which an Obſervation can be made with great Facility; for the Obſerver may place himſelf in the moſt convenient Part of the Ship, where there is the leaſt Motion and Wind to diſturb him, and ſitting on a Stool or the Deck, holding the Inſtrument with his left Hand under the horizon Vane *E z*, and his Right at the End of the Label *F*, with his Thumb thereon, keeping the Label on the ſame Height or Level with his Eye, bring the left convex Surface of the Mercury to appear juſt viſible above the central Ring *E*, and the Shade or *Speculum* of the Sun from the Solar Vane *k*, to coincide therewith on the central Line *E z*; and the Sum of Degrees and Minutes cut on the two Arches by the Vane *k*, and the End of the Label *F*, will give, as uſual, the Angle of the Sun's Co-altitude. As the Sun riſes, the Shade will fall below the central Line (the Surface in its proper Place); and when it paſſes the Meridian, and falls, it will appear above, ſo that the End of the Label muſt be moved in the ſame manner as the Sight Vane uſually is.

To obſerve by a Star, another Perſon muſt look through the Slit on the Horizon Vane, and over the upper Edge of the Shade Vane, and bring the Star to coincide

coincide therewith, proceeding in the ſame manner as before, with the Sun.

There are two very oppoſite Cauſes of an obſcure Horizon; the one proceeds from thick hazy Weather, and the other from fine, clear and calm Weather, as I have often experienced at Sea: I have been running with a Freſh of Wind, ſometimes five, ſix and ſeven Days together, the Diſtance of 2 or 300 Leagues, without an Obſervation; and on the ſixth, ſeventh or eighth Day, it has proved ſtark calm and clear Weather, but the Sea ſo ſmooth, and ſo like in Colour to the Sky, that the Edge or Circle of the ſenſible Horizon could not be diſtinguiſhed therefrom, and conſequently no Obſervation to be made by the Inſtruments then in Practice.

By this Improvement to *Davis*'s Quadrant, the above Obſtacles are intirely removed; ſo that an Obſervation can be made off of Headlands, in Harbours, on Shore, and, in ſhort, anywhere that a Sight of the Sun, *&c.* can be obtained, without any regard had to the Horizon; and, what is peculiar to it, is, that the true Level will be preſerved, as well on the Top of the higheſt Mountain, as cloſe to the Surface of the Horizon. The Apparatus is ſo contrived, that an Obſervation can be made with the ſenſible Horizon as uſual, by means of the Sight Vane *N*, fixed near the End of the Label for that Purpoſe, ſo that the one will be a Proof to the other.

As the Succeſs of Inventions in all things of this kind muſt be confirmed by Experiments only, among many others, two were effectually made on board his Majeſty's Ship *the Oxford* at *Spithead*, in a high Wind,

when

when the Motion was ſhort and quick, and conſequently, a greater Diſadvantage than if on the high Sea, where the Motion is grave, ſlow and regular, occaſion'd by long Waves; but notwithſtanding this quick Motion, the Obſervation made, exactly agreed with the Latitude of the Place; as will more evidently appear by the Report hereunto annex'd, ſigned by all the Principal Officers that were then on board.

THE new Improvement made by Mr. *Charles Leigh* to *Davis's* Quadrant, conſiſting of a Mercurial Level, for taking the Sun or Stars Altitude at Sea, when the ſenſible Horizon is obſcur'd either by thick and hazy Weather, or in ſmooth Calms, when the Sky and Horizon are not diſtinguiſhable, was tried on board this Ship, when the Latitude by Obſervation made with the ſaid Inſtrument agrees, as appears by the following Calculations; *viz.*

March the 9th, high Winds, and a quick Motion.			*March* 10th, ditto Weather.		
	°	″		°	″
Sun's Zenith Diſt.	50	30	Zenith Diſtance	50	38
Sun's Declination		15 S.	Declination		9 N.
Lat. by Obſerv.	50	45	Lat. by Obſerv.	50	47

From which Experiment we judge this Inſtrument ſufficiently accurate for diſcovering the Latitude, and removing that grand Impediment that

fre-

frequently happens by an obſcure Horizon, and conſequently to be of great Uſe in Navigation.

From on board his Majeſty's
Ship Oxford, *at* Spithead,
March 10. 1738.

Signed,

Thomas Strachey, *firſt Lieutenant.*
Thomas Griffin, *Lieutenant.*
James Irving, *Maſter.*
William Slanning, *ſecond Maſter.*

Note, The Latitude of *Spithead* the neareſt is about . . . . 50° 46′ North.

Directions concerning the Quadrant, *&c.*

THE Alteration made in this Inſtrument is greatly for the better, for the Level of Water requir'd to be trim'd every Time of Obſervation, beſides the Hazard of ſpilling the Water from a great Motion; but in this Level of Mercury, the firſt Trimming ſerves always, and without hazard of ſpilling, being cloſe confin'd, as will be ſeen in the Inſtrument.--- The Cylinders are made large enough to receive the Air that will be condens'd and rarefied alternately by the vibratory Motion of the Quickſilver through the ſmall glaſs Tubes, without affecting the true Level Line, as will be found upon Trial: Notwithſtanding, the included Air has no Communication with the External, its being cloſe confin'd gives this Advantage, that it prevents the Mercury, in its vibratory Motion, from being quick and tremulous.

The Bottoms of the braſs Cylinder that the glaſs Tubes are fix'd in, muſt in the Inſide be made Tunnel-wiſe, that the Mercury may not lodge behind. The Hole at the Top, and the Pin, is for taking out or putting in Mercury, if Occaſion; as alſo to clean the Tubes with a Wire. The perpendicular Tubes muſt at leaſt be twice the Diameter of the long Baſe Tube, for this Reaſon among others, that the dilating and condenſing of the Mercury, from Heat or Cold, may not be ſenſible in the perpendicular Tubes; and alſo that the Baſe Tube muſt be as long as the Index or Label will admit, and the Tube thereof to be as ſmall as can be, but ſo as to admit a Paſſage for the Mercury. This Paſſage ſhould be through a ſmall glaſs Tube incloſed in Wood, *&c.* The Cylinders muſt not be ſolder'd with ſoft Solder nor Silver: The Mercury will affect it.

Note, If the Mercury ſhould be ſeparated by an Air-bubble in the Tube, incline the Inſtrument till the Mercury diſappears in the Tube below the Baſe, and it will take it out. The true Level is when the little convex Surfaces of the Mercury juſt appear above the Level Rings; then it is rightly trimm'd; and when you obſerve, you look only at one of them, *viz.* that at the Centre, the Shade Vane co-inciding at the ſame time on the Horizon Vane.

March 11. 1738.